Theory and Simulation: Overview and Plans

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MUTAC Review
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Outline

- overview of simulation activities in NFMCC
- present some neutrino factory front-end results
- discuss our near-term simulation plans

NFMCC simulation activities (1)

(1) perform design simulations for future muon-based facilities

- neutrino factory
- muon collider

major facility design areas

- proton driver
- target
- front-end
- acceleration
- storage or collider ring

NFMCC simulation activities (2)

(2) related simulation efforts inside the collaboration
- MICE experiment (ionization cooling)
- MERIT experiment (liquid targetry)
- RF breakdown
- solid target shock
- small ring coolers

(3) Muons Inc
- separate effort funded by SBIR
- main focus on low-emittance muon colliders
- active collaboration within NFMCC

Study 2a

- Study 2a = design written up in APS Joint Study on the Future of Neutrino Physics (2004)
- this is an update on NFMCC Neutrino Factory Study 2 (2001)
  - contained some BNL site-specific aspects
- new front end design
  - adiabatic RF bunching and phase rotation
  - simplified cooling channel
- new accelerator design with A_T = 30 mm rad
  - dog-bone RLA
  - FFAG accelerators
- Study 2b = design written up in PRSTAB **9**,011001 (2006)

Recent simulation highlights

- participation in International Scoping Study

  aim to focus and consolidate neutrino factory machine options

  workshops

  CERN in September 2005

  BNL in December 2005

  KEK in January 2006

- enhanced interest in muon colliders

  successful LEMC workshop February 2006

  two new schemes based on bunch coalescence

- machine design publications in Phys. Rev. STAB

  RFOFO cooling ring http://prst-ab.aps.org/abstract/PRSTAB/v8/i6/e061003

  Study 2a neutrino factory design http://prst-ab.aps.org/abstract/PRSTAB/v9/i1/e011001

MUTAC meeting simulation guide

- many simulation topics will be covered at this review
- ISS neutrino factory results to date

    comparison of neutrino factory schemes (R. Palmer)
    π production (H. Kirk)
    phase rotation & bunching (D. Neuffer)
    acceleration (S. Berg)
    storage rings (C. Johnstone)
- muon collider

    collider schemes with bunch merging (R. Palmer)
    collider simulations (D. Summers)
    Muons Inc. (R. Johnson)
- experiment-related simulations

    targetry (R. Samulyak, N. Simos)
    MICE (A. Blondel)
    RF breakdown (J. Norem)

ISS front-end tasks

1. compare performance of existing neutrino factory schemes
   - overview (R. Palmer)
2. evaluate implications of reduced rf gradient ←
3. search for optimized front-end systems
   - optimum beam-target combination (H. Kirk)
   - combined phase rotation and cooling (D. Neuffer)
   - spiral cooling channel (D. Summers)
   - effect of curved rf windows ←
   - Study 2a missing cavity sensitivity ←
4. trade-off of cooling versus accelerator acceptance
5. evaluate suitability of windows/absorbers for 2 signs, 4 MW ←

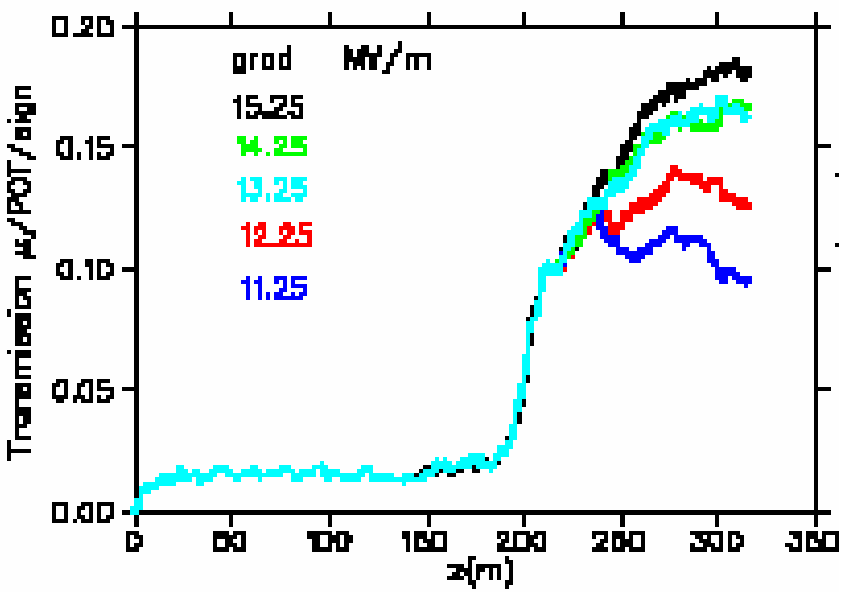
Effect of reduced rf gradient

- what if we can't achieve 15.25 MV/m in a magnetic field?
- operation with 2/3 gradient reduces performance by 20%

  compensated by adjusting amount of absorber and rf phase
- another study assumed construction gives distribution of gradients

  best to put highest gradients at start of channel

  12 full gradient cavities restored performance loss



(J. Gallardo)

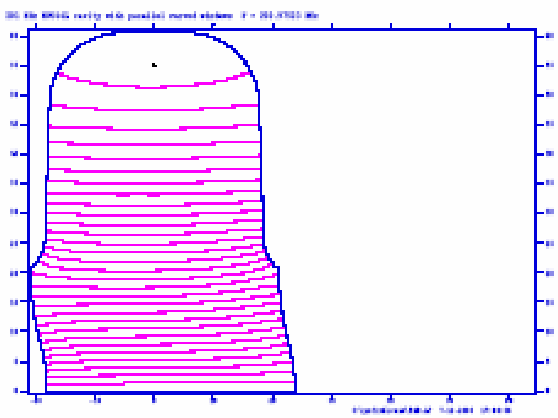
Effect of curved rf windows

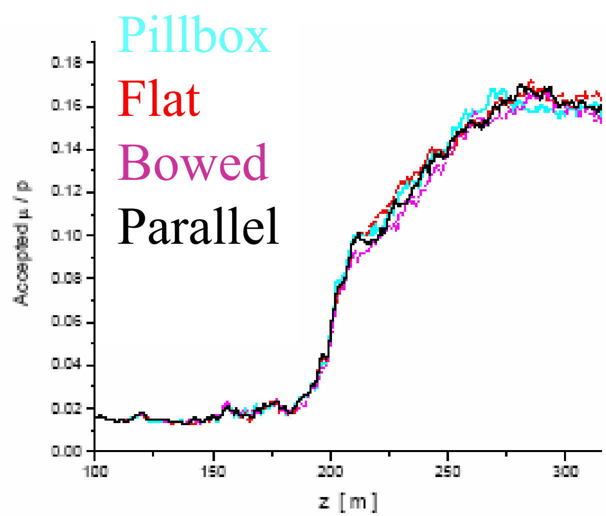
- Study 2a used flat rf windows
- actual curved windows introduce radial electric fields

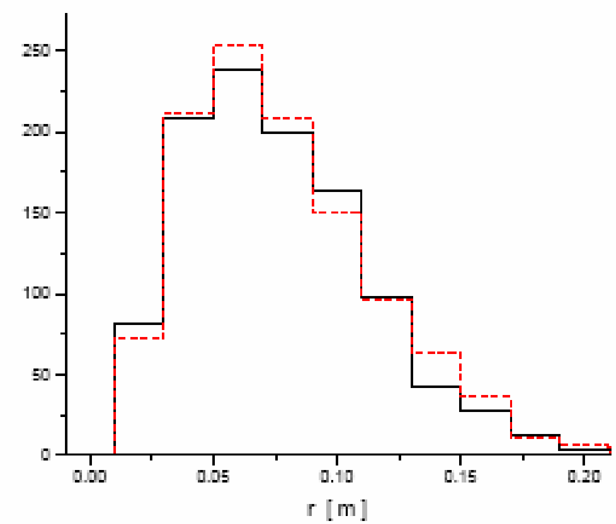
  peak E_R is 17% of peak E_Z near corner of the window
- used SuperFish fields with real curved windows
- saw no significant change in front-end performance

  6% loss reducing window radius from 25 → 21 cm

  (Study 2a → MUCOOL cavity shape)

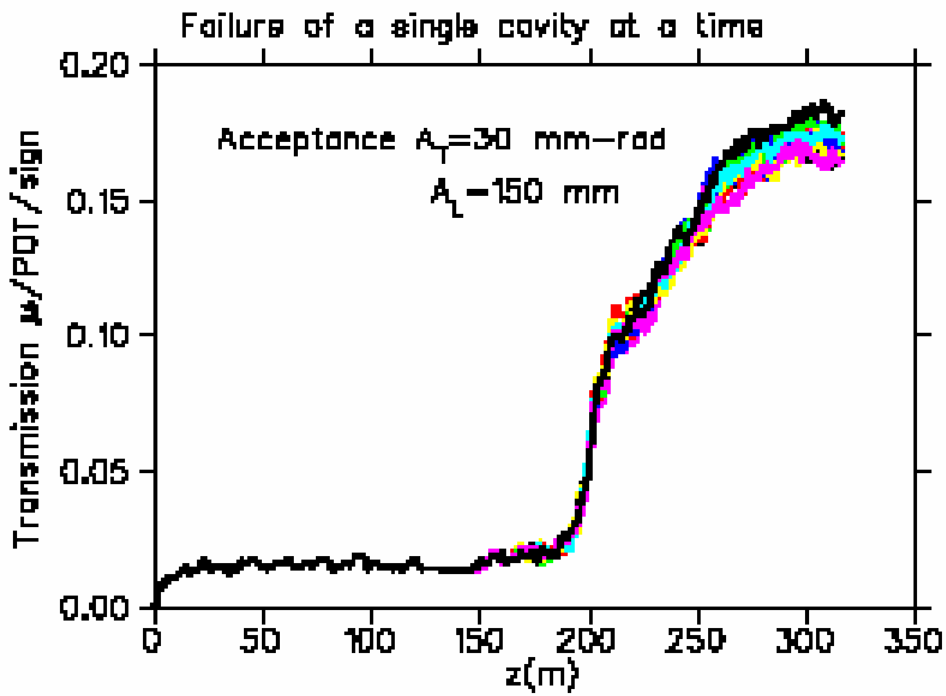






Failure of an rf cavity in Study 2a

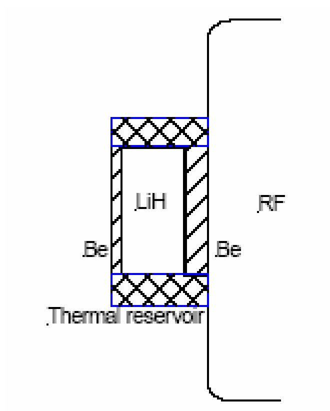
- looked at failure of single cavities in rotator or cooling channel
- find ~3% loss in μ_A/p



(J. Gallardo)

Heating in Study 2a absorber window

- Study 2a neutrino factory design keeps both μ signs
- gives more heating in absorber windows
- this 1-D calculation shows design with conduction cooling possible for 1 MW p beam
- 3-D finite element analysis will be done
- have scheme with flowing He gas if additional cooling needed
- experimental measurements on LiH proposed at MTA



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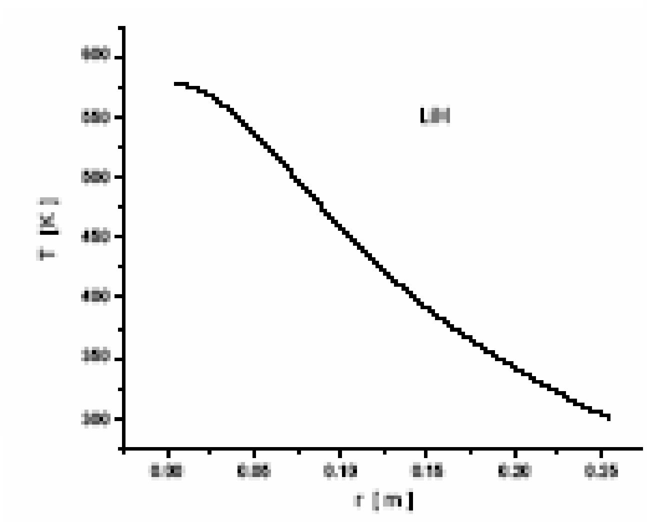

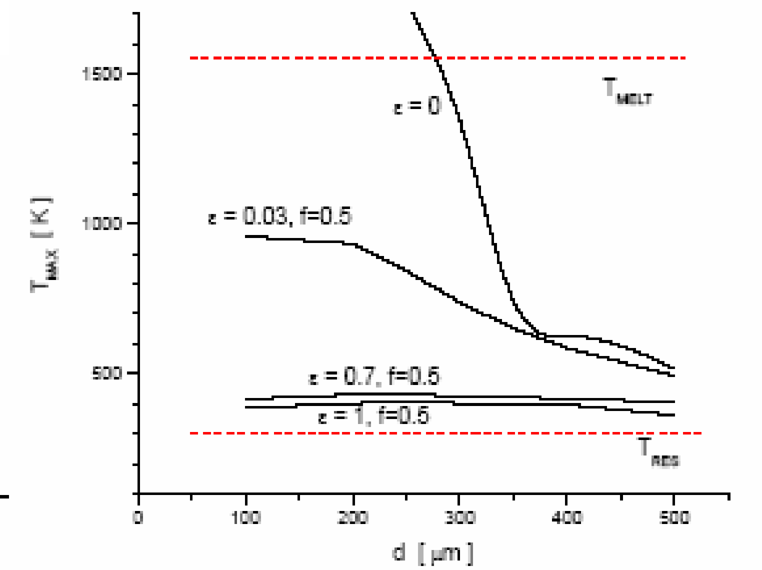

Near-term plans

- neutrino factory

    continue investigating refinements to Study 2a

    finish work on International Scoping Study (NuFact06)

    begin new design work based on ISS conclusions?

- muon collider

    continue investigation of more NF-compatible schemes

        bunch coalescence

        spiral cooling channels and cooling rings

        final cooling using 50 T solenoids

    collaborate with Muons Inc on the very low emittance approach

Summary

- have active program of simulation work
- our major emphasis has been neutrino factory
  - Study 1 → Study 2 → Study 2a → Study2b → ISS
- longer term interest in a muon collider
- continued to make progress in all areas last year
- plan to continue this work in the coming year